Table 10
HOUSEHOLD BENEFITS OF WATER SUPPLY TREATMENT IN THE U.S.
FOR 1970

DISCOUNT RATE = 10%

SUPPLY SOURCE	PER CAPITA BENEFITS ($) AT VARIOUS LEVELS (PCT) OF WATER QUALITY IMPROVEMENT				
	10%	20%	30%	40%	50%
TDS AND HARDNESS					
TREATED SURFACE	0.58	1.16	1.74	2.31	2.89
TREATED GROUND	1.10	2.20	3.29	4.38	5.47
PRIVATE WELL	1.23	2.46	3.68	4.90	6.11
TOTAL	0.86	1.72	2.58	3.44	4.29
TDS ONLY					
TREATED SURFACE	0.19	0.39	0.53	0.77	0.96
TREATED GROUND	0.38	0.76	1.13	1.51	1.87
PRIVATE WELL	0.39	0.77	1.15	1.52	1.89
TOTAL	0.29	0.57	0.86	1.14	1.41
HARDNESS ONLY					
TREATED SURFACE	0.39	0.77	1.16	1.54	1.93
TREATED GROUND	0.72	1.44	2.16	2.88	3.60
PRIVATE WELL	0.84	1.69	2.53	3.38	4.22
TOTAL	0.58	1.15	1.73	2.30	2.88

Table 10 (continued).

SUPPLY SOURCE	PER CAPITA BENEFITS ($) AT VARIOUS LEVELS (PCT) OF WATER QUALITY IMPROVEMENT				
	60%	70%	80%	90%	100%
TDS AND HARDNESS					
TREATED SURFACE	3.46	4.04	4.61	5.19	5.78
TREATED GROUND	6.55	7.64	8.71	9.79	10.89
PRIVATE WELL	7.32	8.53	9.73	10.94	12.15
TOTAL	5.14	5.99	6.84	7.69	8.56
TDS ONLY					
TREATED SURFACE	1.15	1.34	1.53	1.72	1.92
TREATED GROUND	2.24	2.60	2.96	3.32	3.70
PRIVATE WELL	2.26	2.62	2.98	3.34	3.72
TOTAL	1.69	1.97	2.24	2.51	2.80
HARDNESS ONLY					
TREATED SURFACE	2.32	2.70	3.09	3.47	3.86
TREATED GROUND	4.32	5.04	5.76	6.47	7.19
PRIVATE WELL	5.07	5.91	6.75	7.59	8.44
TOTAL	3.45	4.03	4.60	5.18	5.75

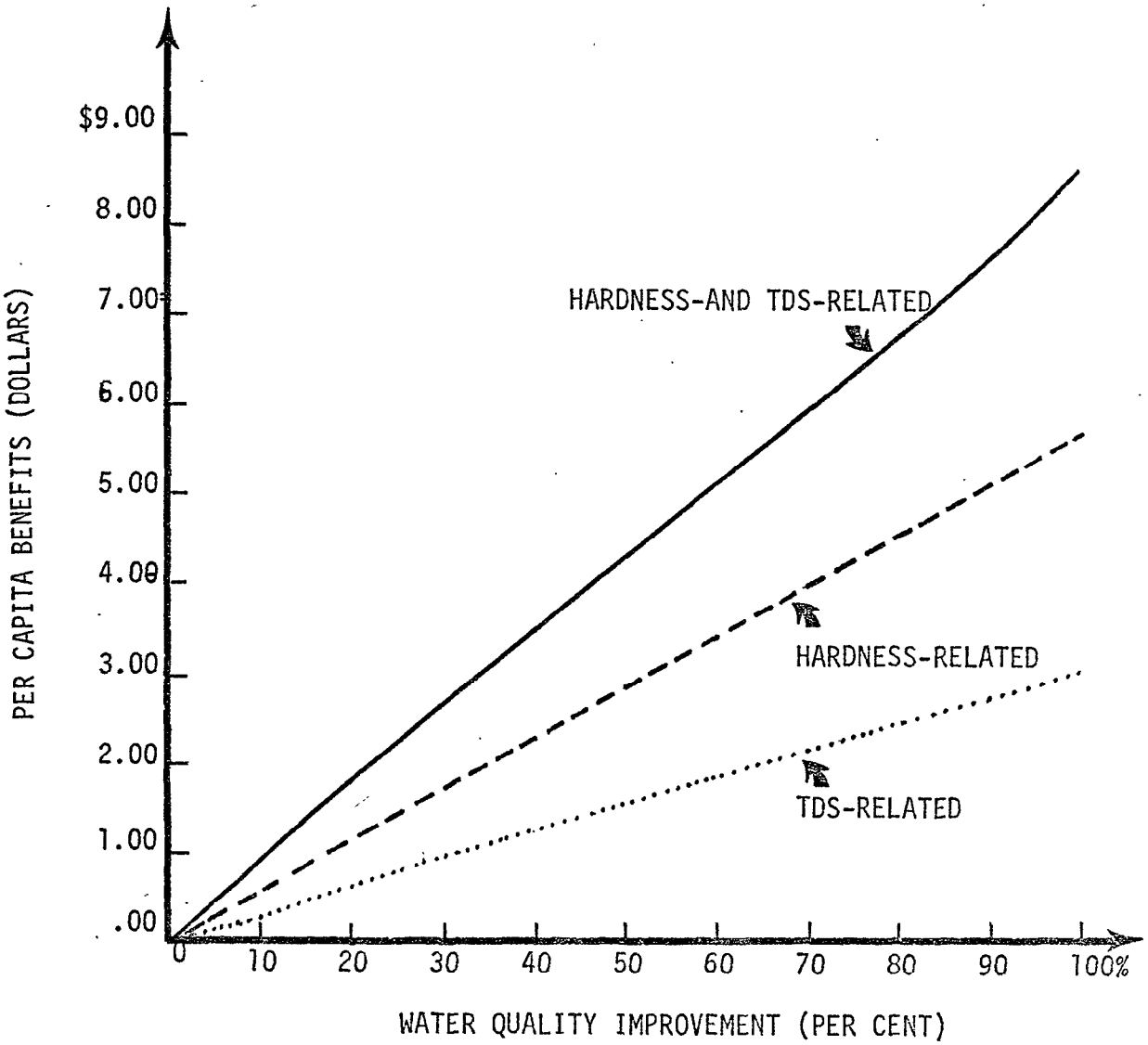


Fig. 4 1970 PER CAPITA BENEFITS OF WATER SUPPLY TREATMENT IN THE UNITED STATES BY WATER QUALITY PARAMETER.

Toward the upper end, some convex relations, i.e., equipment service life and excess detergents to counteract hardness, prevail. For practical purposes, however, the damage curve can be assumed as approximately linear over the removal efficiency range.

Figures 5 and 6 contrast damages associated with the primary sources of intake water. Per capita damages are ostensibly higher with ground water since it generally contains more minerals than surface supplies. Municipal plants normally bypass these constituents without treatment, while the absence of economies of scale preclude their removal from private systems. The next figure transforms these benefits into total population equivalents. In spite of the low per capita contribution from surface supplies, its share of total benefits exceeds one-third. Total benefits to private well owners rank last. This ordering follows from the distribution of water supplies among U.S. households: surface, 50.8%; treated ground, 29.3%; and private well water, 19.9%.

It is important to recognize that these estimates are derived from mean values of household unit damage observations. Because most observations are few in number, the sample mean may not accurately reflect the actual mean for U.S. households. Moreover, "typical" water quality data are compiled for these calculations, but again these figures may not be representative of actual conditions. Because of the uncertainties involved, a range of estimates is preferable to a point value. Figure 7 presents "interval estimates" in each state.

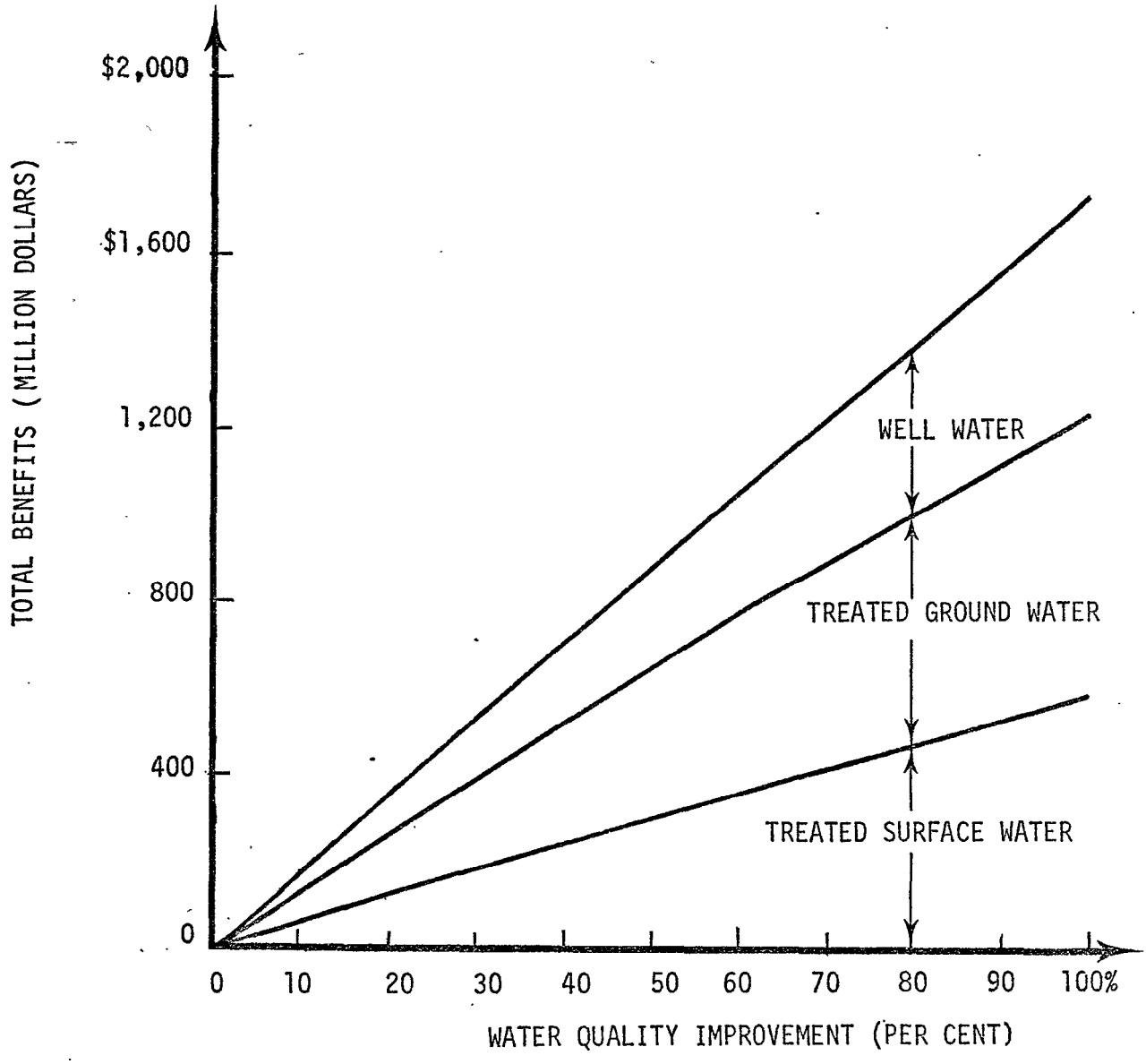


Fig. 5. 1970 TOTAL HOUSEHOLD BENEFITS OF WATER SUPPLY TREATMENT IN THE UNITED STATES, CUMULATED BY SOURCE.

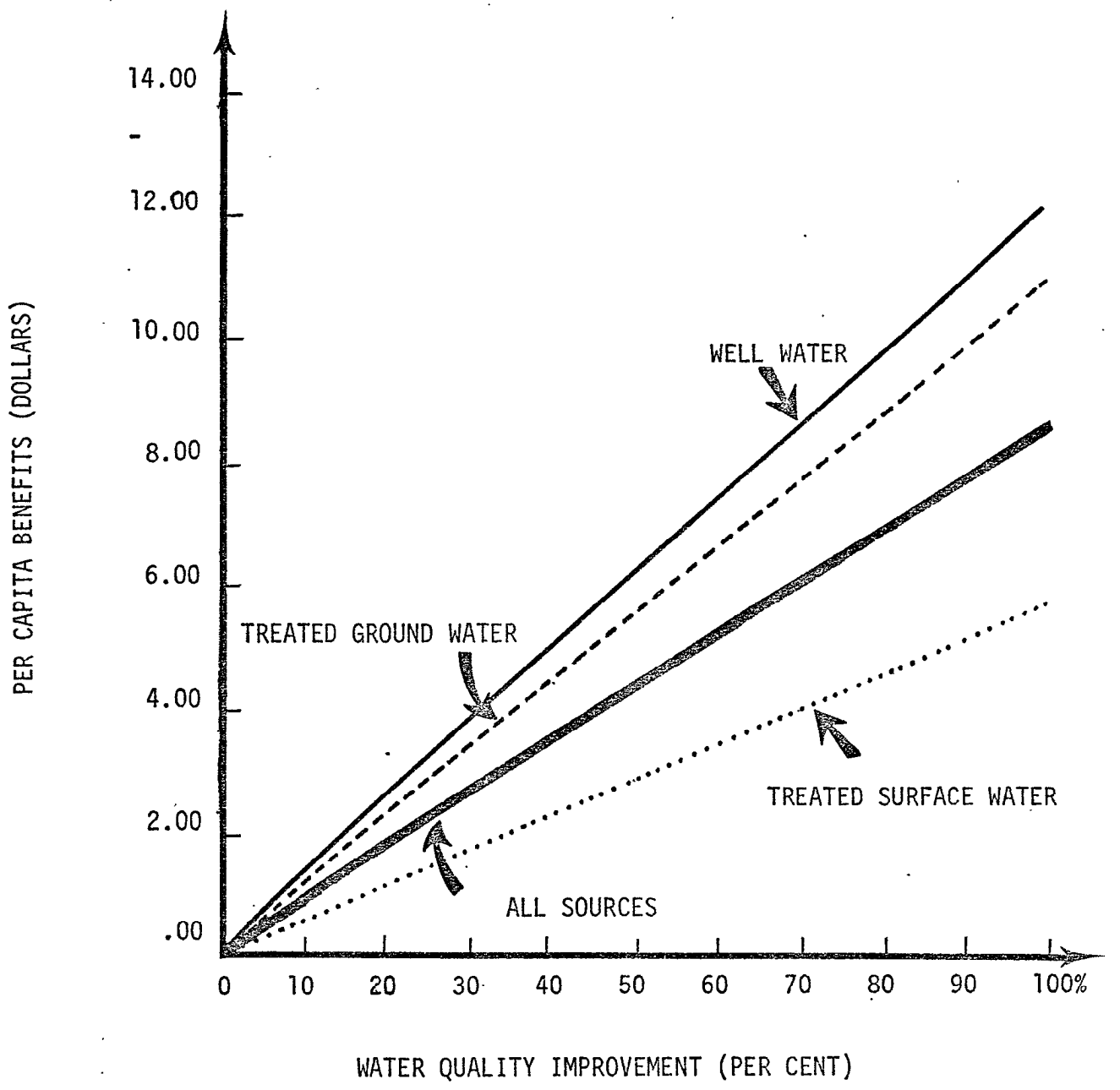
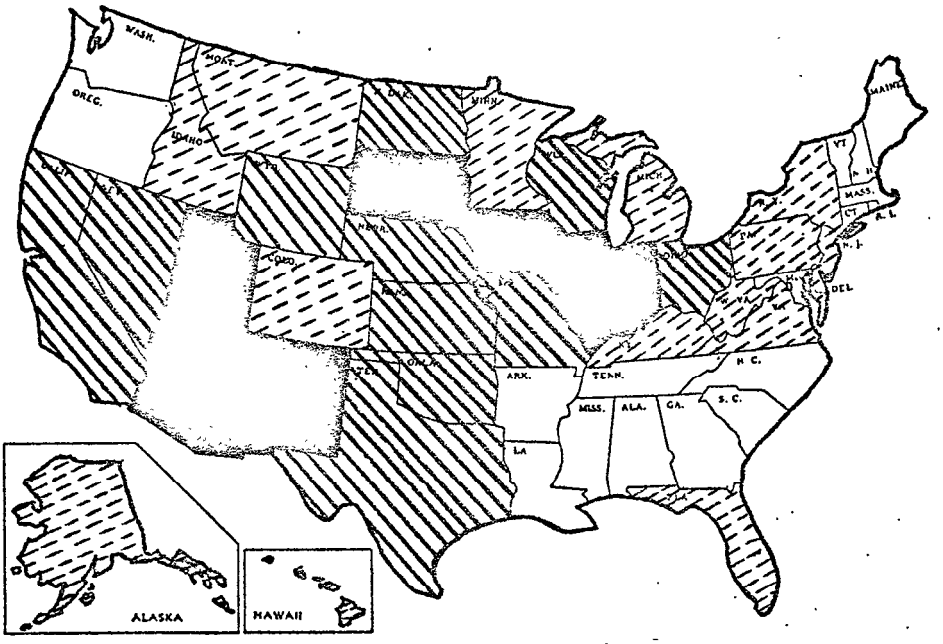


Fig. 6. 1970 PER CAPITA BENEFITS OF WATER SUPPLY TREATMENT IN THE UNITED STATES BY INDIVIDUAL SOURCE.



$15.00 - $24.99

$10.00 - $14.99

$ 5.00 - $ 9.99

$ .00 - $ 4.99

Fig. 7. 1970 PER CAPITA DAMAGES FROM DOMESTIC WATER SUPPLY USE IN THE UNITED STATES.

A range of values can be obtained by deriving confidence limits for each damage function and statistically aggregating them to yield confidence bands of total damages. To do so requires calculations and data requirements beyond the scope of this study. However, an approximate range is derivable by a straightforward method.

Extra soap costs due to hardness contribute almost two-thirds of total damages. From above referenced surveys, per capita costs for every 100 ppm increase in hardness vary from $1.55 to $8.21. If this range is applied to national estimates, total damages from hardness are between $0.43 and $2.27 billion with a mean of $1.15 billion. Standard errors of regressions for other household units also show a large spread about the mean. Assuming the same proportionate range as hardness-related costs, total U.S. damages are within $0.65 - $3.45 billion. On a per capita basis, the corresponding range is $3.21 - $17.06 given a mean of $8.63

SECTION IX

SPECIAL WATER QUALITY CONSIDERATIONS

The above benefits are based on typical water quality observations, which are generally within recommended TDS standards of 500 ppm. It is thus unlikely that damaging agents in these water supplies will be removed in municipal plants unless benefit-cost comparisons show otherwise. Consequently, these benefits will probably not be realized in the near future. On the other hand, U.S. communities whose public water supplies contain TDS in excess of mandatory limits of 1,000 ppm are monitored (Patterson and Banker, 1970) if their population exceeds 1,000. Because these concentrations are so high, they are prime candidates for special treatment or control.

Economic damages for these communities are estimated by above methods, where TDS levels in each community are weighted by population served. Hardness levels in state calculations are assumed, although levels in these communities are probably higher. This assumption contributes, of course, to an underestimate of total damages.

Economic damages to these communities are in the range, $8.2 - $43.5 million with a mean of $22.0 million (at 7.5% interest). The number of people served is slightly over 900,000, which gives per capita damages of $9.09 - $48.26 with an average of $24.41. These estimates assume complete removal of water quality constituents.

The average benefits realized by meeting TDS limits of 500 ppm

are almost $10.00 per individual. For the nation these savings amount to $8.9 million. This total is probably quite low since communities with fewer than 1,000 people are not added in the calculations.

SECTION X

CONCLUDING REMARKS

This study presented damage estimates for the residential use of water. First, the literature was culled, and methods for calculating damages were evaluated. Next, based on these results, a computational algorithm was derived to predict household benefits from water quality enhancement. Last, state and national estimates were predicted for various discount rates and sources of water supply. Total damages to U.S. households are in the range, $0.65 to $3.45 billion. The mean estimate is almost $1.75 billion, of which $0.66 billion is attributed to treated ground water supplies, $0.59 billion to surface water bodies, and $0.49 to privately owned wells (and, in a few instances, local streams). Hardness is the most damaging water constituent, costing $1.14 billion annually compared to $0.61 billion for total dissolved solids. Every 10% improvement of water quality increases national benefits by approximately $175 million. Average damages to the individual exceed $8.50. The typical rural resident on well water, however, faces $12.23 in damages, compared to $5.75 for the majority of urban residents supplied with surface water. On an individual state basis, per capita damages are highest in the Southwest (Arizona, $22.18) and the Midwest (Illinois, $18.24), but lowest in the Southeast (South Carolina, $1.12), New England (Massachusetts, $2.14), and the Northwest (Oregon, $1.69). Total

damages, proportional to population, are highest in California ($225.7 million), Illinois ($163.3 million), and Texas ($126.6 million).

These estimates are conservative since they neglect household expenses for lawn irrigation, disposal of water softening salts and other residues, swimming pool maintenance, extra purchase of dishes, etc. Municipal water quality data were selected for the largest cities, which usually have cleaner water than small towns. The recent Patterson and Banker survey (1969) lists over 400 small U.S. communities whose public water supplies contain more than 1,000 ppm TDS. Only the major water quality factors, TDS and hardness, are assessed in this study. A more complete analysis would include other damaging agents, such as chlorides, iron, and acidity.

SECTION XI

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The opinions expressed in this paper are those of the author and do not represent the official position of the Environmental Protection Agency.

SECTION XII

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APPENDIX

COMPUTER PROGRAM

AND

INPUT DATA

```
FORTRAN IV G LEVEL  20                MAIN              DATE = 72310          15/33/29          PAGE 0

                C     PURPOSE...
                C          CALCULATE 1970 BENEFITS, BY STATE AND BY DISCOUNT RATE, FOR
                C          HOUSEHOLD USE OF WATER SUPPLY AT VARIOUS QUALITIES.
                C          DISTINGUISH USAGE OF TREATED SURFACE, TREATED GROUND, AND
                C          PRIVATE WELL WATER SOURCES.
0001                 DIMENSION BEN(19,2,51,3,2),INCOME(52),POPUL(52),USBEN(4,11),
                    1FAMILY(52),STBEN(52,4),X(51,3),Y(51,3),SUPPLY(52,4),STATE(52,4),
                    2STCOST(52,4),SOURCE(4,4),USHARD(4,11),USTDS(4,11)
0002                 REAL R,RX,INCOME
                C     CAPITAL RECOVERY FACTOR...
0003                 ALPHA(RX,NX)=(RX*(1.+RX)**NX)/((1.+RX)**NX-1.)
                C     INPUT DATA...
                C          X(I,J)=TDS IN STATE I FROM WATER SUPPLY SOURCE J,
                C          Y(I,J)=HARDNESS IN STATE I FROM WATER SUPPLY SOURCE J,
                C          INCOME(I)=INCOME IN STATE I (=52 FOR U.S.),
                C          POPUL(I)=POPULATION IN STATE I,
                C          FAMILY(I)=FAMILY POPULATION IN STATE I,
                C          SUPPLY(I,J)=PERCENTAGE OF STATE I POPULATION USING SOURCE J.
0004                 DO 50 I=1,52
0005                 READ(5,1020) (STATE(I,L),L=1,4),INCOME(I),POPUL(I),FAMILY(I),
                    1(SUPPLY(I,J),J=1,3)
0006                50 CONTINUE
0007                 DO 60 I=1,51
0008                 READ(5,1010) (X(I,J),J=1,3),(Y(I,J),J=1,3)
0009                60 CONTINUE
0010                1010 FORMAT(20X,6F10.1)
0011                1020 FORMAT(4A4,4X,3F10.0,2PF10.1,2PF10.1,2PF10.1)
0012                 READ(5,1025) ((SOURCE(J,L),L=1,4),J=1,4)
0013                1025 FORMAT(4(4X,4A4))
                C     INITIALIZE DISCOUNT RATE...
0014                 R=.025
                C     CALCULATE ALL BENEFITS USING VARIOUS DISCOUNT RATES...
0015                 DO 950 IP=1,3
0016                 R=R+.025
                C     BENEFITS BY DEGREE OF WATER QUALITY IMPROVEMENT...
0017                 DO 400 IPART=1,11
0018                 IP(IPART.EQ.1) IP=1
0019                 IF(IPART.GT.1) IP=2
0020                 PCT=110-10*IPART
                C     BENEFITS BY SUPPLY SOURCE...
0021                 DO 380 J=1,3
0022                 DO 300 I=1,51
0023                 XPART=X(I,J)*PCT/100.
0024                 YPART=Y(I,J)*PCT/100.
                C     ANNUALIZED CAPITAL COSTS BY HOUSEHOLD UNIT...
0025                 ADJ=INCOME(I)/INCOME(52)
0026                 N=12.+EXP(3.40565)*EXP(-.00179*XPART)
0027                 BEN(1,1,I,J,IP)=250.*1.127*ALPHA(R,N)*ADJ*SUPPLY(I,J)
0028                 N=10.+EXP(3.78496)*EXP(-.00764*XPART)
0029                 BEN(2,1,I,J,IP)=450.*1.122*ALPHA(R,N)*ADJ*SUPPLY(I,J)
0030                 N=5.+EXP(2.42483)*EXP(-.00139*XPART)
0031                 BEN(3,1,I,J,IP)=110.*1.050*ALPHA(R,N)*ADJ*SUPPLY(I,J)
0032                 N=-.00275*XPART+11.5
0033                 BEN(4,1,I,J,IP)=105.*1.116*ALPHA(R,N)*ADJ*SUPPLY(I,J)
0034                 N=2.+EXP(2.30303)*EXP(-.00195*XPART)
0035                 BEN(5,1,I,J,IP)=20.*1.116*ALPHA(R,N)*ADJ*SUPPLY(I,J)
0036                 N=5.+EXP(1.55415)*EXP(-.00116*XPART)
0037                 BEN(6,1,I,J,IP)=0.*1.050*ALPHA(R,N)*ADJ*SUPPLY(I,J)
```

```
0038              X=5.+EXP(1.82445)*EXP(-.00079*XPART)
0039              BEN(7,1,I,J,IP)=120.*1.050*ALPHA(R,N)*ADJ*SUPPLY(I,J)
0040              X=-.0007*XPART+10.1750
0041              BEN(8,1,I,J,IP)=20.*1.050*ALPHA(R,N)*ADJ*SUPPLY(I,J)
0042              X=-.00013*XPART+4.6333
0043              BEN(9,1,I,J,IP)=1080.*1.082*ALPHA(R,N)*ADJ*SUPPLY(I,J)
0044              X=-.0033*XPART+30.8333
0045              BEN(10,1,I,J,IP)=120.*1.120*ALPHA(R,N)*ADJ*SUPPLY(I,J)
0046              X=60.+EXP(3.91927)*EXP(-.00091*XPART)
0047              BEN(11,1,I,J,IP)=450.*1.120*ALPHA(R,N)*ADJ*SUPPLY(I,J)
0048              X=-.0033*XPART+50.8333
0049              BEN(12,1,I,J,IP)=60.*1.120*ALPHA(R,N)*ADJ*SUPPLY(I,J)
0050              X=-.0067*XPART+46.6667
0051              BEN(13,1,I,J,IP)=100.*1.120*ALPHA(R,N)*ADJ*SUPPLY(I,J)
0052              X=-.0020*XPART+30.5
0053              BEN(14,1,I,J,IP)=40.*1.120*ALPHA(R,N)*ADJ*SUPPLY(I,J)
0054              X=-.0033*XPART+30.8333
0055              BEN(15,1,I,J,IP)=90.*1.120*ALPHA(R,N)*ADJ*SUPPLY(I,J)
0056              BEN(16,1,I,J,IP)=0.
0057              BEN(17,1,I,J,IP)=0.
0058              X=12.
0059              BEN(18,1,I,J,IP)=.0007*YPART*300.*1.000*ALPHA(R,N)*ADJ*SUPPLY(I,J)
0060              BEN(19,1,I,J,IP)=0.
          C       ANNUAL OPERATION AND MAINTENANCE COSTS BY HOUSEHOLD UNIT...
0061              BEN(1,2,I,J,IP)=1.120*(.00113*XPART+2.01667)*ADJ*SUPPLY(I,J)
0062              BEN(2,2,I,J,IP)=1.120*(.0007*XPART+1.6250)*ADJ*SUPPLY(I,J)
0063              BEN(3,2,I,J,IP)=1.050*(.00127*XPART+16.8117)*ADJ*SUPPLY(I,J)
0064              BEN(4,2,I,J,IP)=1.116*(.0007*XPART+1.6250)*ADJ*SUPPLY(I,J)
0065              BEN(5,2,I,J,IP)=1.116*(.00157*XPART+.6083)*ADJ*SUPPLY(I,J)
0066              BEN(6,2,I,J,IP)=1.050*(.00005*XPART+.1125)*ADJ*SUPPLY(I,J)
0067              BEN(7,2,I,J,IP)=1.050*(.00102*XPART+3.345)*ADJ*SUPPLY(I,J)
0068              BEN(8,2,I,J,IP)=0.
0069              BEN(9,2,I,J,IP)=0.
0070              BEN(10,2,I,J,IP)=1.120*(.00031*XPART+4.5225)*ADJ*SUPPLY(I,J)
0071              BEN(11,2,I,J,IP)=1.120*(.00115*XPART+3.1633)*ADJ*SUPPLY(I,J)
0072              BEN(12,2,I,J,IP)=1.120*(.00063*XPART+.34167)*ADJ*SUPPLY(I,J)
0073              BEN(13,2,I,J,IP)=0.
0074              BEN(14,2,I,J,IP)=1.120*(.00023*XPART+.5917)*ADJ*SUPPLY(I,J)
0075              BEN(15,2,I,J,IP)=1.120*(.00023*XPART+3.3919)*ADJ*SUPPLY(I,J)
0076              BEN(16,2,I,J,IP)=1.082*(.0027*XPART+11.6500)*ADJ*SUPPLY(I,J)
0077              BEN(17,2,I,J,IP)=1.000*EXP(-3.72725)*(XPART**.80420)*ADJ*SUPPLY(I,
                 1J)
0078              BEN(18,2,I,J,IP)=1.000*.1594*YPART*(.0007*YPART)*ADJ*SUPPLY(I,J)
0079              BEN(19,2,I,J,IP)=1.000*(.1578*YPART*(1.0-.0007*YPART)+11.6500)*
                 1ADJ*SUPPLY(I,J)
0080            300 CONTINUE
          C       NATIONAL BENEFITS SUMMED OVER STATE BENEFITS...
0081              USBEN(J,IPART)=0.
0082              USHARD(J,IPART)=0.
0083              IF(IPART.EQ.1) GO TO 360
0084              DO 350 ICOST=1,2
0085              DO 350 I=1,51
0086              DO 340 IUNIT=1,19
          C       MARGINAL BENEFITS OF CLEANUP RELATIVE TO POORFST WATER QUALITY...
0087              USBEN(J,IPART)=(BEN(IUNIT,ICOST,I,J,1)-BEN(IUNIT,ICOST,I,J,2))*
                 1FAMILY(I)+USBEN(J,IPART)
0088            340 CONTINUE
0089              USHARD(J,IPART)=(BEN(18,ICOST,I,J,1)+BEN(19,ICOST,I,J,1)-
```

```
     1BEN(18,ICOST,I,J,2)-BEN(19,ICOST,I,J,2))*FAMILY(I)+USHARD(J,IPART)
0090      350 CONTINUE
0091          USTDS(J,IPART)=USBEN(J,IPART)-USHARD(J,IPART)
0092          GO TO 380
0093      360 CONTINUE
0094          DO 370 ICOST=1,2
0095          DO 370 I=1,51
0096          DO 365 IUNIT=1,19
          C   TOTAL DAMAGES OF USING POOREST WASTER QUALITY...
0097          USBEN(J,IPART)=BEN(IUNIT,ICOST,I,J,1)*FAMILY(I)+USBEN(J,IPART)
0098      365 CONTINUE
0099          USHARD(J,IPART)=(BEN(18,ICOST,I,J,1)+BEN(19,ICOST,I,J,1))*
     1FAMILY(I)+USHARD(J,IPART)
0100      370 CONTINUE
0101          USTDS(J,IPART)=USBEN(J,IPART)-USHARD(J,IPART)
0102      380 CONTINUE
0103          USBEN(4,IPART)=0.
0104          USHARD(4,IPART)=0.
0105          USTDS(4,IPART)=0.
0106          DO 390 J=1,3
0107          USBEN(4,IPART)=USBEN(J,IPART)+USBEN(4,IPART)
0108          USHARD(4,IPART)=USHARD(J,IPART)+USHARD(4,IPART)
0109          USTDS(4,IPART)=USTDS(J,IPART)+USTDS(4,IPART)
0110      390 CONTINUE
0111      400 CONTINUE
          C   STATE-BY-STATE COMPARISON OF BENEFITS...
0112          STCOST(52,4)=0.
0113          STBEN(52,1)=0.
0114          STBEN(52,2)=0.
0115          STBEN(52,3)=0.
0116          STBEN(52,4)=0.
0117          DO 520 I=1,51
0118          DO 500 J=1,3
0119          STCOST(I,J)=0.
0120          STBEN(I,J)=0.
0121          DO 500 IUNIT=1,19
0122          DO 500 ICOST=1,2
0123          STCOST(I,J)=BEN(IUNIT,ICOST,I,J,1)*FAMILY(I)+STCOST(I,J)
0124          STBEN(I,J)=(BEN(IUNIT,ICOST,I,J,1)-BEN(IUNIT,ICOST,I,J,2))*
     1FAMILY(I)+STBEN(I,J)
0125      500 CONTINUE
0126          STCOST(I,4)=STCOST(I,1)+STCOST(I,2)+STCOST(I,3)
0127          STBEN(I,4)=STBEN(I,1)+STBEN(I,2)+STBEN(I,3)
          C   COMPUTE STATE BENEFIT TOTALS...
0128          STCOST(52,4)=STCOST(I,4)+STCOST(52,4)
0129          STBEN(52,1)=STBEN(I,1)+STBEN(52,1)
0130          STBEN(52,2)=STBEN(I,2)+STBEN(52,2)
0131          STBEN(52,3)=STBEN(I,3)+STBEN(52,3)
0132          STBEN(52,4)=STBEN(I,4)+STBEN(52,4)
0133      520 CONTINUE
0134          IF(S.GT..05) GO TO 800
          C   PRINT INPUT DATA REQUIREMENTS...
0135          WRITE(6,1050)
0136     1050 FORMAT(1H1,60X,'INPUT DATA',/////,52X,'WATER SUPPLY SOURCE (PCT)',
         16X,'TDS IN SOURCE (PPM)',9X,'HARD. IN SOURCE (PPM)',/,8X,'STATE'
         2,7X,'POPULATION',2X,'FAMILIES',2X,'INCOME',3X,'SURFACE',2X,
         3'TR.GROUND',1X,'RAW WELL',4X,'SURF.',2X,'TR.GR.',2X,'RAW WL.',2X,
         4'SURF.',2X,'TR.GR.',2X,'RAW WL.',/)
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0137              DO 700 I=1,52
0138              IF(I.EQ.52) WRITE(6,1060) (STATE(I,L),L=1,4),POPUL(I),FAMILY(I),
                 1INCOME(I),(SUPPLY(I,J),J=1,3)
0139              IF(I.EQ.52) GO TO 709
0140              WRITE(6,1070) (STATE(I,L),L=1,4),POPUL(I),FAMILY(I),INCOME(I),
                 1(SUPPLY(I,J),J=1,3),(X(I,J),J=1,3),(Y(I,J),J=1,3)
0141          700 CONTINUE
0142         1060 FORMAT(/,3X,4A4,1X,F10.0,1X,F9.0,2X,F6.0,4X,2PF4.1,7X,F4.1,5X,
                 1F4.1)
0143         1070 FORMAT(3X,4A4,1X,F10.0,1X,F9.0,2X,F6.0,4X,2PF4.1,7X,F4.1,5X,F4.1,
                 15X,OPF5.1,5(3X,F5.1))
0144          800 CONTINUE
             C      PRINT BENEFIT ESTIMATES FOR EACH DISCOUNT RATE...
             C      LIST BENEFITS BY STATE...
0145              WRITE(6,1080) R
0146         1080 FORMAT(1H1,42X,'HOUSEHOLD DAMAGES OF WATER SUPPLY USE BY STATE',
                 1/,61X,'FOR 1970',
                 1//,55X,'DISCOUNT RATE = ',F4.3,///,26X,'HOUSEHLD EXPND',11X,
                 1'TOTAL DAMAGES ($1 M) BY SOURCE',14X,'PER CAPITA DAMAGES ($) BY SO
                 2URCE',/,8X,'STATE',11X,'TOTAL',3X,'PER CAPITA',4X,'SURFACE',3X,
                 3'TR.GROUND',3X,'RAW WELL',5X,'TOTAL',5X,'SURFACE',3X,'TR.GROUND',
                 43X,'RAW WELL',5X,'TOTAL',/)
0147              DO 810 I=1,52
0148              COS4PC=STCOST(I,4)/POPUL(I)
0149              BEN1PC=STBEN(I,1)/(POPUL(I)*SUPPLY(I,1))
0150              BEN2PC=STBEN(I,2)/(POPUL(I)*SUPPLY(I,2))
0151              BEN3PC=STBEN(I,3)/(POPUL(I)*SUPPLY(I,3))
0152              BEN4PC=STBEN(I,4)/POPUL(I)
0153              WRITE(6,1090) (STATE(I,L),L=1,4),STCOST(I,4),COS4PC,STBEN(I,1),
                 1STBEN(I,2),STBEN(I,3),STBEN(I,4),BEN1PC,BEN2PC,BEN3PC,BEN4PC
0154          810 CONTINUE
0155         1090 FORMAT(4X,4A4,2X,-6PF7.1,3X,OPF7.2,6X,-6PF7.1,4X,F7.1,4X,F7.1,
                 15X,F7.1,4X,OPF7.2,3(4X,F7.2))
             C      LIST BENEFITS FOR THE UNITED STATES...
0156              WRITE(6,1100) R
0157         1100 FORMAT(1H1,41X,'HOUSEHOLD BENEFITS OF WATER SUPPLY TREATMENT IN TH
                 1E U.S.',/,60X,'FOR 1970',
                 1//,55X,'DISCOUNT RATE = ',F4.3,///,22X,'TOTAL',/,21X,
                 2'HOUSEHLD',16X,'TOTAL BENEFITS ($1 M) AT VARIOUS LEVELS (PCT) OF W
                 3ATER QUALITY IMPROVEMENT',/,3X,'SUPPLY SOURCE',5X,'EXPND',5X,'10%'
                 4,7X,'20%',7X,'30%',7X,'40%',7X,'50%',7X,'60%',7X,'70%',7X,'80%',
                 57X,'90%',6X,'100%',/)
0158              WRITE(6,1130)
0159         1130 FORMAT(//,' TDS AND HARDNESS')
0160              DO 850 J=1,4
0161              WRITE(6,1110) (SOURCE(J,L),L=1,4),(USBEN(J,IPART),IPART=1,11)
0162          850 CONTINUE
0163              WRITE(6,1160)
0164         1160 FORMAT(//,' TDS ONLY')
0165              DO 860 J=1,4
0166              WRITE(6,1110) (SOURCE(J,L),L=1,4),(USTDS(J,IPART),IPART=1,11)
0167          860 CONTINUE
0168              WRITE(6,1170)
0169         1170 FORMAT(//,' HARDNESS ONLY')
0170              DO 870 J=1,4
0171              WRITE(6,1110) (SOURCE(J,L),L=1,4),(USHARD(J,IPART),IPART=1,11)
0172          870 CONTINUE
0173              WRITE(6,1150) R
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0174          1150 FORMAT(1H1,36X,'HOUSEHOLD BENEFITS OF WATER SUPPLY TREATMENT IN TH
                  1E U.S.',/,60X,'FOR 1970',
                  1//,55X,'DISCOUNT RATE = ',F4.3,///,18X,'PER CAPITA',/,
                  219X,'HOUSEHLD',12X,'PER CAPITA BENEFITS ($) AT VARIOUS LEVELS (PCT
                  3) OF WATER QUALITY IMPROVEMENT',//,3X,'SUPPLY SOURCE',5X,'EXPND',
                  45X,'10%',7X,'20%',7X,'30%',7X,'40%',7X,'50%',7X,'60%',7X,'70%',7X,
                  5'80%',7X,'90%',6X,'100%',/)
0175                WRITE(6,1130)
0176                DO 900 J=1,4
0177                IF(J.EQ.4) SUPPLY(52,J)=1.00
0178                DO 890 IPART=1,11
0179                USBEN(J,IPART)=USBEN(J,IPART)/(POPUL(52)*SUPPLY(52,J))
0180                USHARD(J,IPART)=USHARD(J,IPART)/(POPUL(52)*SUPPLY(52,J))
0181                USTDS(J,IPART)=USTDS(J,IPART)/(POPUL(52)*SUPPLY(52,J))
0182           890  CONTINUE
0183          1110  FORMAT(2X,4A4,1X,-6PF7.1,11(3X,-6PF7.1))
0184                WRITE(6,1120) (SOURCE(J,L),L=1,4),(USBEN(J,IPART),IPART=1,11)
0185           900  CONTINUE
0186          1120  FORMAT(2X,4A4,1X,F7.2,11(3X,F7.2))
0187                WRITE(6,1160)
0188                DO 910 J=1,4
0189                WRITE(6,1120) (SOURCE(J,L),L=1,4),(USTDS(J,IPART),IPART=1,11)
0190           910  CONTINUE
0191                WRITE(6,1170)
0192                DO 920 J=1,4
0193                WRITE(6,1120) (SOURCE(J,L),L=1,4),(USHARD(J,IPART),IPART=1,11)
0194           920  CONTINUE
0195           950  CONTINUE
0196                END
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INPUT DATA
FOR
DAMAGE CALCULATIONS

STATE	POPULATION	FAMILIES	INCOME ($)	WATER SUPPLY SOURCE (PCT) SURFACE	TR.GROUND	RAW WELL
MAINE	992048	248154	9045	58.1	14.9	27.0
MASSACHUSETTS	5689170	1390982	12238	65.7	24.3	10.0
VERMONT	444330	107411	10099	41.2	21.8	37.0
NEW HAMPSHIRE	737681	183825	10776	38.0	35.0	27.0
CONNECTICUT	3031709	767651	13795	63.3	19.7	17.0
RHODE ISLAND	946725	236667	11041	67.4	22.6	10.0
NEW YORK	18236960	4609638	12491	67.3	22.7	10.0
NEW JERSEY	7168164	1838809	13025	34.3	30.7	35.0
DIST. COLUMBIA	756510	163482	12189	95.0	0.0	5.0
PENNSYLVANIA	11793909	3011130	10877	74.0	12.0	14.0
WEST VIRGINIA	1744237	454493	8195	51.4	24.6	24.0
MARYLAND	3922399	974143	12682	75.8	10.2	14.0
VIRGINIA	4648494	1162256	10568	62.2	9.8	28.0
DELAWARE	548104	136915	11771	39.5	44.5	16.0
KENTUCKY	3218706	825222	8560	57.6	9.4	33.0
TENNESSEE	3923687	1024446	8619	45.8	28.2	26.0
MISSISSIPPI	2216912	534444	7292	11.5	63.5	25.0
ALABAMA	3444165	874659	8412	48.7	26.3	25.0
GEORGIA	4589575	1149771	9491	42.2	25.8	32.0
NORTH CAROLINA	5082059	1292466	8872	42.2	13.8	44.0
SOUTH CAROLINA	2590516	628689	8577	65.6	14.4	20.0
FLORIDA	6789443	1811367	10120	8.2	66.8	25.0
OHIO	10652017	2691130	11488	53.7	22.3	24.0

INPUT DATA (continued).

STATE	POPULATION	FAMILIES	INCOME ($)	WATER SUPPLY SOURCE (PCT) SURFACE	TR.GROUND	RAW WELL
INDIANA	5193669	1321674	10959	39.9	30.1	30.0
ILLINOIS	11113976	2794194	12338	50.9	29.1	20.0
MICHIGAN	8875083	2190269	12296	64.1	15.9	20.0
WISCONSIN	4417731	1077475	11135	35.3	34.7	30.0
MINNESOTA	3804971	921332	11098	34.1	40.9	25.0
ARKANSAS	1923295	505195	7459	32.3	30.7	37.0
LOUISIANA	3641306	872772	8799	41.2	38.8	20.0
OKLAHOMA	2559229	679256	9100	58.0	22.0	20.0
TEXAS	11196730	2818123	9955	47.4	46.6	6.0
NEW MEXICO	1016000	242740	9193	6.3	60.7	33.0
MISSOURI	4676501	1204751	10236	61.0	19.0	20.0
IOWA	2824376	717776	10138	20.0	60.0	20.0
NEBRASKA	1483493	374160	9792	15.1	64.9	20.0
KANSAS	2246578	581849	10063	40.1	39.9	20.0
NORTH DAKOTA	617761	148235	9086	31.8	29.2	39.0
SOUTH DAKOTA	665507	161941	8795	15.4	34.6	50.0
MONTANA	694409	171812	9662	48.3	20.7	31.0
WYOMING	332416	84703	10127	36.0	39.0	25.0
UTAH	1059273	249741	10428	32.4	36.6	31.0
COLORADO	2207259	547165	10875	76.1	13.9	10.0
CALIFORNIA	19953120	5001255	12227	54.4	40.6	5.0
ARIZONA	1770900	438389	10501	26.5	51.5	22.0
NEVADA	488783	124170	11872	33.1	49.9	17.0
HAWAII	768561	170729	13077	3.5	71.5	25.0
WASHINGTON	3409169	862542	11511	55.0	33.0	12.0
OREGON	2091385	542483	10695	52.8	22.2	25.0
IDAHO	712567	179448	9455	9.2	59.8	31.0
ALASKA	300382	66670	13056	27.9	27.1	45.0

INPUT DATA (continued).

STATE	TDS IN SOURCE (PPM) SURF.	TR.GR.	RAW WL.	HARD, IN SOURCE (PPM) SURF.	TR.GR.	RAW WL.
MAINE	33.0	89.0	144.0	20.0	62.0	103.0
MASSACHUSETTS	27.0	93.0	158.0	11.0	47.0	82.0
VERMONT	64.0	95.0	126.0	51.0	67.0	82.0
NEW HAMPSHIRE	36.0	106.0	175.0	12.0	50.0	87.0
CONNECTICUT	59.0	105.0	151.0	33.0	51.0	68.0
RHODE ISLAND	51.0	64.0	72.0	30.0	30.0	30.0
NEW YORK	64.0	283.0	177.0	40.0	191.0	106.0
NEW JERSEY	71.0	121.0	121.0	42.0	67.0	67.0
DIST. COLUMBIA	201.0	201.0	201.0	135.0	135.0	135.0
PENNSYLVANIA	136.0	184.0	232.0	81.0	141.0	201.0
WEST VIRGINIA	117.0	190.0	262.0	70.0	118.0	166.0
MARYLAND	89.0	104.0	118.0	57.0	51.0	44.0
VIRGINIA	100.0	130.0	160.0	59.0	101.0	142.0
DELAWARE	89.0	191.0	191.0	48.0	101.0	103.0
KENTUCKY	202.0	227.0	251.0	101.0	148.0	195.0
TENNESSEE	123.0	83.0	96.0	83.0	40.0	67.0
MISSISSIPPI	95.0	124.0	153.0	45.0	43.0	40.0
ALABAMA	119.0	132.0	144.0	69.0	66.0	63.0
GEORGIA	44.0	91.0	151.0	23.0	50.0	124.0
NORTH CAROLINA	69.0	110.0	151.0	42.0	55.0	68.0
SOUTH CAROLINA	52.0	62.0	72.0	17.0	13.0	8.0
FLORIDA	212.0	250.0	235.0	148.0	123.0	171.0
OHIO	196.0	190.0	420.0	114.0	107.0	337.0
INDIANA	263.0	419.0	382.0	195.0	350.0	327.0
ILLINOIS	157.0	291.0	460.0	128.0	279.0	347.0

INPUT DATA (continued).

STATE	TDS IN SOURCE (PPM) SURF.	TR.GR.	RAW WL.	HARD. IN SOURCE (PPM) SURF.	TR.GR.	RAW WL.
MICHIGAN	136.0	198.0	260.0	100.0	162.0	224.0
WISCONSIN	162.0	303.0	331.0	129.0	289.0	289.0
MINNESOTA	112.0	205.0	298.0	65.0	166.0	267.0
ARKANSAS	40.0	155.0	270.0	21.0	72.0	123.0
LOUISIANA	185.0	231.0	215.0	78.0	2.0	31.0
OKLAHOMA	223.0	418.0	664.0	147.0	138.0	314.0
TEXAS	238.0	429.0	706.0	102.0	178.0	205.0
NEW MEXICO	250.0	604.0	873.0	73.0	263.0	408.0
MISSOURI	207.0	488.0	488.0	75.0	236.0	236.0
IOWA	244.0	393.0	542.0	108.0	233.0	357.0
NEBRASKA	382.0	312.0	428.0	144.0	177.0	263.0
KANSAS	374.0	325.0	504.0	163.0	121.0	301.0
NORTH DAKOTA	314.0	602.0	890.0	131.0	130.0	129.0
SOUTH DAKOTA	196.0	596.0	994.0	86.0	206.0	325.0
MONTANA	193.0	364.0	535.0	115.0	110.0	104.0
WYOMING	200.0	202.0	500.0	123.0	169.0	301.0
UTAH	224.0	548.0	492.0	183.0	216.0	310.0
COLORADO	136.0	200.0	937.0	77.0	100.0	495.0
CALIFORNIA	254.0	382.0	380.0	105.0	146.0	170.0
ARIZONA	720.0	730.0	550.0	239.0	307.0	254.0
NEVADA	91.0	235.0	256.0	40.0	206.0	187.0
HAWAII	211.0	211.0	211.0	60.0	60.0	60.0
WASHINGTON	41.0	141.0	118.0	21.0	127.0	83.0
OREGON	22.0	99.0	99.0	5.0	41.0	41.0
IDAHO	136.0	208.0	350.0	102.0	131.0	210.0
ALASKA	100.0	146.0	146.0	67.0	114.0	114.0